

Pharmaceuticals

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Personal

Products

PPCPs

Care

in the environment

PPCPs

Care

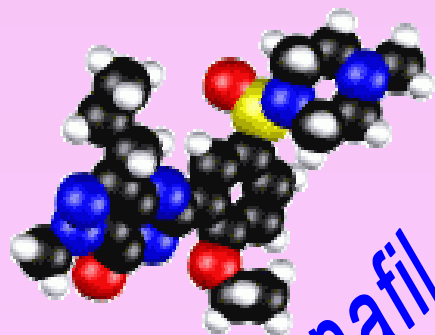
Personal

Products

Pharmaceuticals

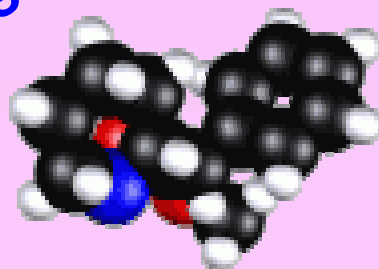
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Environmental Aspects of Pharmaceuticals and Personal Care Products

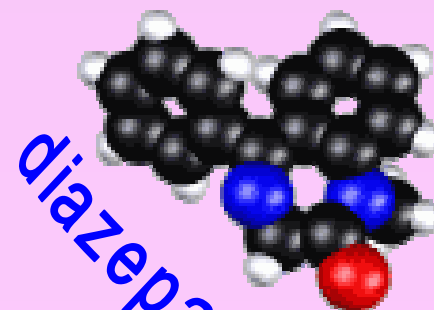


sildenafil

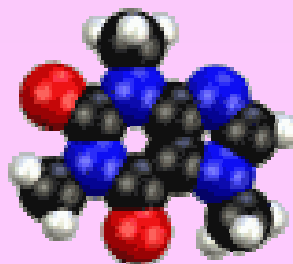
methylphenidate



ibuprofen

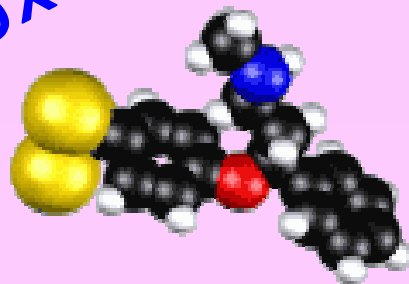


diazepam



caffeine

fluoxetine



ranitidine



Pharmaceuticals and Personal Care Products (PPCPs) as Environmental Pollutants

◀ *Pollution from Personal Actions* ▶

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U.S. EPA Notice

The U.S. Environmental Protection Agency (EPA), through its Office of Research and Development (ORD), funded this research and approved the materials that formed the basis for this web-based slide presentation. Unless otherwise indicated, all the materials in this presentation represent the personal and professional views and opinions of Dr. Christian Daughton, and as such, they should not be construed as necessarily reflecting those of the U.S. Environmental Protection Agency.

NOTE

Because of the size of this presentation, this file comprises only the 1st part of the entire PPCPs slide presentation. The subsequent parts must be accessed separately.

U.S. EPA, Office of Research and Development
National Exposure Research Laboratory
Environmental Sciences Division
Las Vegas, Nevada



Goal of this Presentation

Summarize the many inter-related issues/concerns associated with the...

Environmental Ubiety, Ubiquity, Significance, Solutions, and Stewardship of ...

***Personal-Practices Pollutants* —**

chemicals used for Maintaining, Aiding, Enhancing, or Altering ...
Therapy, Diagnosis, Appearance, Performance, Development,
Perception, or Lifestyle ...
or Preventing or Curing Disease ...

as a result of their purposeful and unintended/unavoidable collective discharge to the environment by humans as well as animals.

These slides and many additional materials are available at the U.S. EPA's *PPCPs Web Site*:

<http://www.epa.gov/nerlesd1/chemistry/pharma/index.htm>





URL: <http://www.epa.gov/nrl/chem/str/pharma/index.htm>

U.S. Environmental Protection Agency

National Exposure Research Laboratory Environmental Sciences

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Pharmaceuticals and Personal Care Products (PPCPs) as Environmental Pollutants

Pollution from Personal Actions, Activities, and Behaviors

• About This Site

• Frequently Asked Questions from the Public, Media, and Scientific Communities

• Overview: Pharmaceuticals & Personal Care Products (PPCPs) as Environmental Pollutants

• NEW and prior work from the U.S. EPA ORD Laboratory in Las Vegas

• Literature Citations Relevant to PPCPs in the Environment

- [NEW](#) – Book on Pharmaceuticals in the Environment, from the American Chemical Society
- [NEW](#) – Book on Pharmaceuticals in the Environment, from Springer-Verlag
- [NEW](#) – Discussions regarding the importance of the literature, a literature foreword

• Relevant and Useful Websites

- [NEW](#) – USGS National Water Monitoring Program (includes PPCPs)

• Media Coverage of EPA Activities in PPCPs

• Scientific Conferences Devoted to PPCPs in the Environment

- [Assistance with Conferences, Seminars, or Lectures](#)

• Listing of Scientists Involved with Environmental Aspects of PPCPs

• Research Needs and Gaps

• Grants Awarded for Research on PPCPs

• Opportunities for Funding and for Research in Collaboration with EPA Scientists

• Communicating Science and Science Literacy

• Teaching Environmental Science – Guide to Relevant Materials on PPCPs

• EPA's Terms of Environment (glossary of technical terminology)

• Environmental Chemistry: Measurement • Methods • Quality Assurance • Statistics

This site uses numerous Microsoft Word, Excel, and PDF files. Adobe Acrobat Reader is required to view these documents. The most recent version of the Adobe Acrobat Reader is available as a free download.

An Adobe Acrobat plug-in for selected technologies is also available.

[Analytical Environmental Chemistry Home Page](#)
[PPCPs Home Page](#)

[ORD Home](#) | [NREL Home](#)
 Author: Christine Daughton
 Email: daughton.christine@epa.gov

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Last updated on Friday, May 1, 2009

URL: <http://www.epa.gov/nrel/chem/str/pharma/index.htm>



*Overview and
Local
PPCPs in the
Environment*

About This Site
 FAQ
 Overview
 New & Prior Work
 Relevant Literature
 Literature Foreword
 Useful Websites
 Media Coverage
 Conferences
 Involved Scientists
 Research Needs
 Grants
 Opportunities
 Communicating Science
 Teachers
 Glossary
 Methods/QA/Statistics

This Slide Show Is Continually Evolving.
The original version was first posted in April 2000, as a result of the following presentation:

Daughton, C.G. “Pharmaceuticals in the Environment — Overarching Issues and Concerns,” paper #29, presented at the *219th National Meeting of the American Chemical Society*, session on Pharmaceuticals in the Environment, San Francisco, CA, 27 March 2000 (published in “Issues in the Analysis of Environmental Endocrine Disruptors”, Preprints of Extended Abstracts, vol 40(1), pp. 96-98, 2000).

It has been greatly expanded since then This current version was completed in July 2002.

Who might be interested in this topic?

- Those with a keen interest in the interconnectedness between humans and the environment.
- Some of the information presented here will hopefully lead to new insights, lend new perspectives, and enhance our knowledge of the linkage between humans and the environment.
- The materials presented here should prove of interest not just to those actively engaged in research, but also to educators, students, the public, and environmental risk assessors and policy makers.

Importance of the Published Literature

Immeasurable value of the science literature resides in its use to reveal what is knowable. A complex “garden of knowledge,” the literature is designed to be continually cultivated, grown, harvested, digested, and seeded. In the absence of care, its fruits wither and rot. Neglected and ignored, its vast facts lay strewn about – otherwise capable of revealing much – but in the end, telling nothing.

Science is built up with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house.

[*La Science et l'Hypothese* (1908), Jules Henri Poincaré (1854–1912), French mathematician, physicist, philosopher of science; excerpted from *The Columbia World of Quotations* (1996), quote #44785]

continued -

Importance of the Published Literature

The issues involved with PPCPs in the environment are multi-faceted and involve the science of many disciplines. While the published literature is extremely important to the progress of any discipline, it is even more critical in the pursuit of answers to the many questions posed here.

While the literature potentially holds many answers (from yet-to be-made connections), it is frequently underutilized.

For further discussion of this critical aspect of science, please refer to the discussions regarding the topic of “**Literature Forensics**, available at:

<http://www.epa.gov/nerlesd1/chemistry/forensics.htm>

continued -

Proliferation of Acronyms

The acronym "**PPCPs**" was coined for the critical review article published in *Environmental Health Perspectives* (Daughton & Ternes, 1999).

Other acronyms and terms have since appeared in the literature.

For example, "**PhACs**" (*Pharmaceutically Active Compounds*) was coined by Sedlak et al. (Sedlak, D.L.; Gray, J.L.; Pinkston, K.E. "Understanding micro contaminants in recycled water," *Environ. Sci. Technol.* 2000, 34(23), 509A-515A); while encompassing therapeutically active drugs, PhACs would not include non-therapeutic pharmaceuticals (e.g., diagnostic agents, X-Ray contrast media being one example), nor would it include personal care products (such as synthetic musks).

Another expression that aptly captures the pollution aspect of PPCPs is "**feral pharmaceuticals**", a term coined by Fisher and Borland (Fisher, P.M.J; Borland, R. "Gauging the pharmaceutical burden on Sydney's environment: a preventative response," *J. Cleaner Prod.*, in press (July 2002)).

continued -

Suggestions for Searching the Literature on PPCPs

While the use of acronyms is often a bane of science – at best unnecessarily confusing or at worst obfuscating communication – acronyms can serve useful functions when researching the published literature. This is especially true for the topic of pharmaceuticals and personal care products as environmental pollutants; the search terms “PPCPs” and “PhACs” are extremely useful in this sense (as are citation cross-indexes such as *Science Citation Index*). Searching the literature relevant to PPCPs in the environment is made difficult because there are no search terms specific to the topic. The words "drug", "pharmaceutical," "medicine", "medication", "medicinal product", "diagnostic agent", "personal care product" are much too broad, encompassing a vast, largely irrelevant literature. General searches can be better focused, however, by coupling any combination of these terms (or names of specific PPCPs) with others that are used more specifically in the environmental literature but not in the generic medical literature: "aquatic", "sewage", "manure", "pollutant", "pollution", etc.

continued -

Supporting Documents for this Presentation

In the interest of conserving space, it is not possible to fully reference the points and ideas presented in this slide show – especially since this slide show provides information supplementary to that on the PPCPs web site (and in a greatly distilled format). **This slide show is not intended to stand on its own.** If documentation is sought, the likely places to locate it on this web site are the following pages:

<http://www.epa.gov/nerlesd1/chemistry/ppcp/reference.htm>

<http://www.epa.gov/nerlesd1/chemistry/pharma/new.htm>

<http://www.epa.gov/nerlesd1/chemistry/ppcp/relevant.htm>

- concluded -

Objectives of this Work

- Present an overview and background for the topic: *Environmental Aspects of Pharmaceuticals and Personal Care Products*
- Catalyze and promote further exploration and discussion of the issue by environmental scientists and engineers as well as by all stakeholders.
- Ensure that any regulatory decisions are based on sound science, avoiding being overly or under-protective of ecological or human health and wasting economic resources or jeopardizing health.

Limitations of Discussion

Any topic concerning potential environmental chemical pollution is multifaceted — involving a host of disciplines, including, in this case:

- ▶ *Analytical/Environmental Chemistry* ▶ *Toxicology*
- ▶ *Hydrology* ▶ *Medical Sciences* ▶ *Sanitary Engineering* ▶ *Risk Assessment* ▶ *Policy Making*

The materials presented here do not cover all the aspects of the overall topic, nor can they cover them in depth:

- ▶ *Chemical Analysis (methods for identification & quantitation)* ▶ *Identification of Source/Occurrence*
- ▶ *Environmental Fate* ▶ *Exposure* ▶ *Effects* ▶ *Risk Assessment*
- ▶ *Mitigation* ▶ *Pollution Prevention* ▶ *Regulation* ▶ *Research Planning & Coordination*

continued -

Limitations of Discussion

Several very important aspects of PPCPs are not covered in this presentation (other than in passing).

This presentation emphasizes the environmental science associated with human PPCPs (as opposed to veterinary). The importance, therefore, of confined animal feeding operations (CAFOs) with respect to the environmental disposition of antibiotics and steroids, and the consequences regarding antibiotic resistance and transfer and endocrine disruption are not emphasized. A large literature on these two topics exists, and can be accessed at:

[http://www.epa.gov/nerlesd1/chemistry/ppcp/relevant.htm#Confined Animal Feeding Operations](http://www.epa.gov/nerlesd1/chemistry/ppcp/relevant.htm#Confined%20Animal%20Feeding%20Operations)

[http://www.epa.gov/nerlesd1/chemistry/ppcp/relevant.htm#Imprudent Use of Antibiotics](http://www.epa.gov/nerlesd1/chemistry/ppcp/relevant.htm#Imprudent%20Use%20of%20Antibiotics)

<http://www.epa.gov/nerlesd1/chemistry/ppcp/reference.htm> (search for selected key words)

continued -

Limitations of Discussion

It must be emphasized that many of the points presented here regarding further research or activities are merely suggestions or recommendations intended to further dialog, discussion, or debate among the many stakeholders involved in this multi-faceted issue. They are NOT intended as directives. Finally, it is also important to separate those items reflecting current reality from those that represent mere proposals or potential future concerns.

- *concluded* -

Clarification of Acronyms

Pharmaceuticals & Personal Care Products:
“PPCPs”

Endocrine Disrupting Compounds:
“EDCs”[†]

[†]A plethora of other terms have often been used interchangeably with EDCs (rightly and wrongly). These include: environmental estrogens, endocrine-disruptors, endocrine-modulators, estrogenic mimics, ecoestrogens, environmental hormones, xenoestrogens, hormone-related toxicants, hormonally active agents (HAAs), endocrine-active chemicals (EACs), phytoestrogens (a naturally occurring subset). [Note: estrogens represent but one mode of action – others include androgens]

EDCs vs. PPCPs

PPCPs vs. EDCs  PPCPs \cap EDCs

- PPCPs and EDCs are **not** synonymous — they are intersecting sets.
- Must avoid confusion regarding their relationship.
- Only a small subset of PPCPs are known/suspected of being direct-acting EDCs (e.g., synthetic steroids); toxicological concerns usually differ. EDCs comprise members from many disparate chemical classes.

continued -

Hormones & EDCs

A hormone (“to excite”), as originally introduced by Bayliss and Starling after 1902 (with discovery of secretin regulation of peristalsis), was a biochemical secreted (in the absence of a duct) directly into the blood at a low concentration and which acted upon distant organs or tissues.

continued -

Hormones & EDCs

Original view of hormones and transmitters as comprising distinct families of biochemicals has evolved to the understanding of a much more complex web of interrelated agents that span a spectrum of mechanisms of actions and purposes. The spectrum is defined by the extremes of: neurotransmitters (such as acetylcholine) at one end, and hormones (such as sex steroids) at the other. The two extremes are bridged by a broad continuum of overlapping, interrelated biochemical agents. Because of the extraordinary complexity of these intra- and extra-cellular communication pathways, all of them are inter-related to some degree.

continued -

Hormones & EDCs

A more recent definition of a “hormone” (by Nobel Laureate Roger Guillemin) suggests a much broader definition: "Any substance released by a cell which acts on another cell, near or far..." Hormones are produced in many sites throughout the body and may be released directly into the blood, into neuronal synapses, or into the immediate intercellular space to affect adjacent cellular activity.

Attempts to focus attention on chemicals that can “disrupt” or “modulate” endocrine pathways must be sure to sufficiently narrow the scope of concern — otherwise the issue at hand becomes so broad as to lose meaning.

The ultimate objective of all these signaling molecules (chemical messengers) is to maintain cellular, organ, and organism HOMEOSTASIS and to control physiological processes.

continued -


Endocrine Modulators and Homeostasis

Hormones: secreted from endocrine sources and some neurons; transported by blood to remote targets (nuclear receptors). Regulate gene transcription (e.g., sex steroids). Slow-acting.

Pheromones: secreted by exocrine glands; targets outside body; integrate social activities between animals.

**Endocrine
Physiology**

continuum



biochemical agents for maintaining cellular, organ, and organism
HOMEOSTASIS
and controlling physiological processes

Neuroendocrinology

Neurotransmitters: secreted from neurons and act on immediately adjacent target cells for a short time (e.g., acetylcholine).

Local signaling molecules: secreted from cells of many different tissues; act locally; quickly degraded.

Neurophysiology


EDCs versus PPCPs

Hormones: secreted from endocrine sources and some neurons; transported by blood to remote targets (nuclear receptors). Regulate gene transcription (e.g., sex steroids). Slow-acting.

Pheromones: secreted by exocrine glands; targets outside body; integrate social activities between animals.

EDCs

continuum



biochemical agents for maintaining cellular, organ, and organism **HOMEOSTASIS** and controlling physiological processes

← preponderance of action →

Neurotransmitters: secreted from neurons and act on immediately adjacent target cells for a short time (e.g., acetylcholine).

Local signaling molecules: secreted from cells of many different tissues; act locally; quickly degraded.

PPCPs

Proposed Significant Increase to Federal Research on EDCs

House Bill introduced on 9 May 2002.

The Hormone Disruption Research Act of 2002 would authorize up to \$500 million beginning in FY03 for the National Institute of Environmental Health Sciences (NIEHS) to conduct and coordinate a five-year research program on "hormone disruption".

- *concluded* -

“Disclaimers”

PPCPs entering the environment:

End-Use vs. Manufacturing

- Focus of this discussion is primarily on PPCPs originating from end-use rather than from manufacturing.
- Emphasis is on use/disposal of PPCPs as originating primarily from activities/actions of individuals and to a lesser degree from hospitals and industry – not from the PPCP manufacturing sector (whose waste streams are much better defined, confined, and controlled/controllable).

continued -

“Disclaimers”

PPCPs as an “emerging” environmental issue?

While it is true that this issue had only become topical in the U.S. in the late 1990s, much research had already been accomplished since the 1980s by a number of European and Scandinavian investigators.

- *concluded* -

Conferences on PPCPs

The first all-day symposium in North America on this topic was:

ACS (American Chemical Society) — *Pharmaceuticals and Personal Care Products in the Environment: An Emerging Concern*, 219th National Meeting of the American Chemical Society, San Francisco, CA, 27 March 2000.

(<http://www.acs.org/meetings/sanfran2000/techprog.html>)

This conference served to spawn an ongoing procession of subsequent symposia, conferences, sessions, and workshops. Many of these (past and upcoming) are captured at:

<http://www.epa.gov/nerlesd1/chemistry/ppcp/conference.htm>

Opportunities for Funding and for Research in Collaboration with EPA Scientists

A variety of avenues exist for students, postdoctoral scientists, and established scientists to pursue both funded and volunteer research in environmental science; at times there are even opportunities that specifically target the topic of PPCPs in the environment. Presented below are some of the more common mechanisms allowing pursuit of research under the auspices of, or in collaboration with, U.S. EPA scientists.

Volunteer basis:

U.S. EPA Student Volunteer Program:

<http://intranet.epa.gov/rtpntra7/services/hrmd/staffing/volstmemb.htm>

U.S. EPA Visiting Scientist Program: Requires a brief proposal to EPA collaborators as well as letters of understanding between host EPA facility and the visitor's sponsoring institution.

Funded Basis:

Science to Achieve Results (STAR) Fellowship Program:

<http://es.epa.gov/ncercqa/rfa/>

NNEMS (National Network for Environmental Management Studies) Program:

<http://www.epa.gov/enviroed/students.html>

Science to Achieve Results (STAR) Research Grant Opportunities:

<http://es.epa.gov/ncercqa/rfa>

U.S. EPA STAR Grants

\$3M awarded in September 2001

<http://es.epa.gov/ncer/grants/drinking00.html>

A. Lynn Roberts (Dept. Geography & Environ. Eng., John Hopkins University)

- **Pharmaceuticals and Antiseptics: Occurrence and Fate in Drinking Water, Sewage Treatment Facilities, and Coastal Waters**

Tohren C. G. Kibbey (Dept. Civil Eng. & Environ. Science, Univ. Oklahoma)

- **The Influence of Amphiphilic Molecules on the Environment Fate and Transport of Pharmaceuticals**

Kevin L. Armbrust (Univ. of Georgia - CAES Griffin Campus)

- **The Environmental Occurrence, Fate and Ecotoxicity of Selective Serotonin Reuptake Inhibitors (SSRIs) in Aquatic Environments**

Bruce Brownawell (Marine Sciences Research Center, Stony Brook University)

- **Occurrence and Fate of Pharmaceuticals and Personal Care Products in Groundwater Environments**

David W. Graham; Cynthia Larive (Dept. Environ. Eng., University of Kansas)

- **Fate and Effects of Fluoroquinolone Antibacterial Agents in Aquatic Ecosystems**

Howard S. Weinberg (Dept. Environmental Science and Engineering, Univ. of North Carolina at Chapel Hill)

- **Impact of Residual Pharmaceutical Agents and Their Metabolites in Wastewater Effluents on Downstream Drinking Water Treatment Facilities**

some U.S. EPA Products on PPCPs (as of 2001)

- Daughton, C.G.; Ternes, T.A. “Pharmaceuticals and Personal Care Products in the Environment: Agents of Subtle Change?” *Environ. Health Perspect.* **1999**, 107(suppl 6), 907-938.
- Daughton, C.G.; Jones-Lepp, T. (eds.) Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues, *Symposium Series 791*; American Chemical Society: Washington, D.C., 2001, 416 pp; available at: http://www.oup_usa.org/isbn/0841237395.html (0-8412-3739-5)
- Daughton, C.G. “Pharmaceuticals in the environment: Overarching issues and overview,” in Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues, Daughton, C.G. and Jones-Lepp, T. (eds.), *Symposium Series 791*; American Chemical Society: Washington, D.C., 2001, pp. 2-38.

continued -

U.S. EPA Products on PPCPs

- Daughton, C.G. “Illicit Drugs in Municipal Sewage: Proposed New Non-Intrusive Tool to Heighten Public Awareness of Societal Use of Illicit/Abused Drugs and Their Potential for Ecological Consequences,” in Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues, Daughton, C.G. and Jones-Lepp, T. (eds.), *Symposium Series 791*; American Chemical Society: Washington, D.C., 2001, pp. 348-364.
- Daughton, C.G. “Emerging Pollutants, and Communicating the Science of Environmental Chemistry and Mass Spectrometry: Pharmaceuticals in the Environment,” *J. Am. Soc. Mass. Spectrom.* **2001**, 12(10), 1067-1076.

continued -

U.S. EPA Products on PPCPs

- L.I. Osemwengie, L.I.; Steinberg, S. “On-Site Solid-Phase Extraction and Laboratory Analysis of Ultra-Trace Synthetic Musks in Municipal Effluent, Using Gas Chromatography-Mass Spectrometry, Full-Scan Mode,” *J. Chromatogr. A* **2001**, 932(1-2), 107-118.
- Daughton, C.G. “Drugs in Water Supplies (with sidebar: Properly disposing of unused outdated drugs),” in Water Sciences, Macmillan Science Library, Dasch, J (Ed.); Macmillan Reference USA/Gale Group, Farmington Hills, MI (accepted, targeted for April 2003).

continued -

U.S. EPA Products on PPCPs

- Grange, A.H. et al. **“Environmental Forensics: Identification of Pollutant Unknowns by High Resolution Mass Spectrometry (Ion Composition Elucidation - ICE).”**
Available at:
<http://www.epa.gov/nerlesd1/chemistry/ecb-posters2.htm>
- Daughton, C.G. **“Towards a Green Pharmacy - - Cradle-to-Cradle Stewardship of Drugs for Minimizing Their Environmental Disposition while Promoting Human Health”** submitted June 2002.
- Daughton, C.G. **“Homeostasis Disruption: Unforeseen Effects of PPCPs in the Environment?”** in preparation 2002.

- concluded -

Primary Goals of the U.S. EPA's *Office of Research and Development*

- **Identification of potential (future) environmental concerns:** anticipatory research; emerging issues. Identify pivotal sources of uncertainty that affect risk estimates.
- **Proactive vs. Reactive — Pollution prevention vs. remediation/restoration:** Identify and foster investigation of “hidden” or potential environmental issues/concerns before they become critical ecological or human health problems.
- **Foster interdisciplinary research, collaboration, debate:** Catalyze research by academe, private sector, government.
- **Ruling-in/ruling-out vs. Uninformed rules:** Provide bases for informed decisions. Ensure that science leads eventual decisions for guidance or to regulate/not regulate.

Drivers of Ecological Change

Ecological change is effected by human activities primarily via three routes:

- Habitat disruption/fragmentation.
- Alteration of community structure (e.g., introduction alien/nuisance species).
- Chemical pollution.

The scopes/ramifications of first two are highly delineated compared with chemical pollution.

Grand Challenges in Environmental Sciences

The National Research Council (as requested by the National Science Foundation) synthesized the broad expertise from across the many disciplines embodied in environmental science to offer its judgment as to the *most significant environmental research challenges of the next generation* – based on their “potential to provide a scientific breakthrough of practical importance to humankind if given major new funding”.

Of the eight “grand challenges” identified in the NRC’s report (*Grand Challenges in Environmental Sciences*[†]), two require concerted input from those involved with pollutant identification: (1) “Hydrologic Forecasting” (for predicting changes in freshwater resources as a result in part of chemical contamination) and (2) “Reinventing the Use of Materials”.

[†] National Research Council. *Grand Challenges in Environmental Sciences*; Committee on Grand Challenges in Environmental Sciences, Oversight Commission for the Committee on Grand Challenges in Environmental Sciences, National Academy Press: Washington, DC, 2000, 88 pp. (Prepublication stage) [available: <http://www.nap.edu/books/0309072549/html/>]

Grand Challenges in Environmental Sciences

(continued)

The impetus driving the second (“Reinventing the Use of Materials”) is:

“...new compounds and other substances are constantly being incorporated into modern technology and hence into the environment, with insufficient thought being given to the implications of these actions. All of these issues assume added importance in urban areas, which concentrate flows of resources, generation of residues, and environmental impacts within spatially constrained areas. From a policy standpoint, reliable predictive models of material cycles could be invaluable in guiding decisions about ... topics relating to human-environment interactions...”

“This grand challenge centrally encompasses questions about societal-level consumption patterns, since consumption is the primary force driving human perturbations of material cycles.”

Growing Imperative for Water Re-Use

Key, Critical Driving Force for Management of Water Quality in the 21st Century

WHO World Water Day Report

United Nations drawing international attention to "the most immediate and serious human health and environmental problem facing the planet."

<http://www.worldwaterday.org/news/wwdreport.html>

The Ecological Footprint (Wackernagel and Rees, 1995)

Residents of industrialized countries may need an average of 10-22 acres per capita to support an urban lifestyle. One of the major issues facing water resource managers in the 21st century will be to understand the overall impact of the urban ecological footprint on water resources. While there are numerous consequences of the footprint, a major concern may be the continued use of urban waterways as waste receptacles — merely for diluting and transporting downstream the by-products of urban consumption.

M. Wackernagel and W. Rees Our Ecological Footprint: Reducing Human Impact on the Earth, New Society Publishers, Philadelphia, PA, 1995, 176 pp. ISBN 0-86571-312-X.

“PBTs”, “POPs”, “BCCs”: Only one part of the risk puzzle?

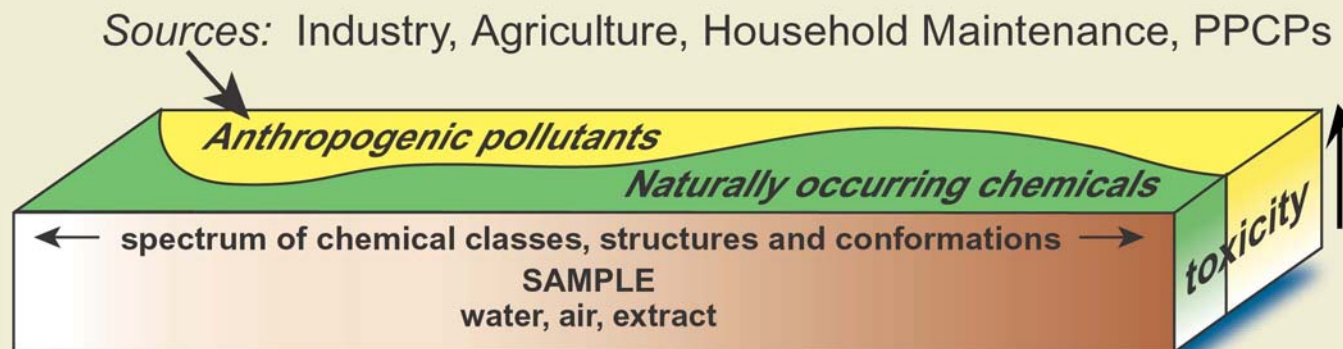
Since the 1970s, the impact of chemical pollution has focused almost exclusively on conventional “priority pollutants”[†], especially on those collectively referred to as “persistent, bioaccumulative, toxic” (PBT) pollutants, “persistent organic pollutants” (POPs), or “bioaccumulative chemicals of concern” (BCCs).

The “dirty dozen” is a ubiquitous, notorious subset of these, comprising highly halogenated organics (e.g., DDT, PCBs).

The conventional priority pollutants, however, are only one piece of the larger risk puzzle.

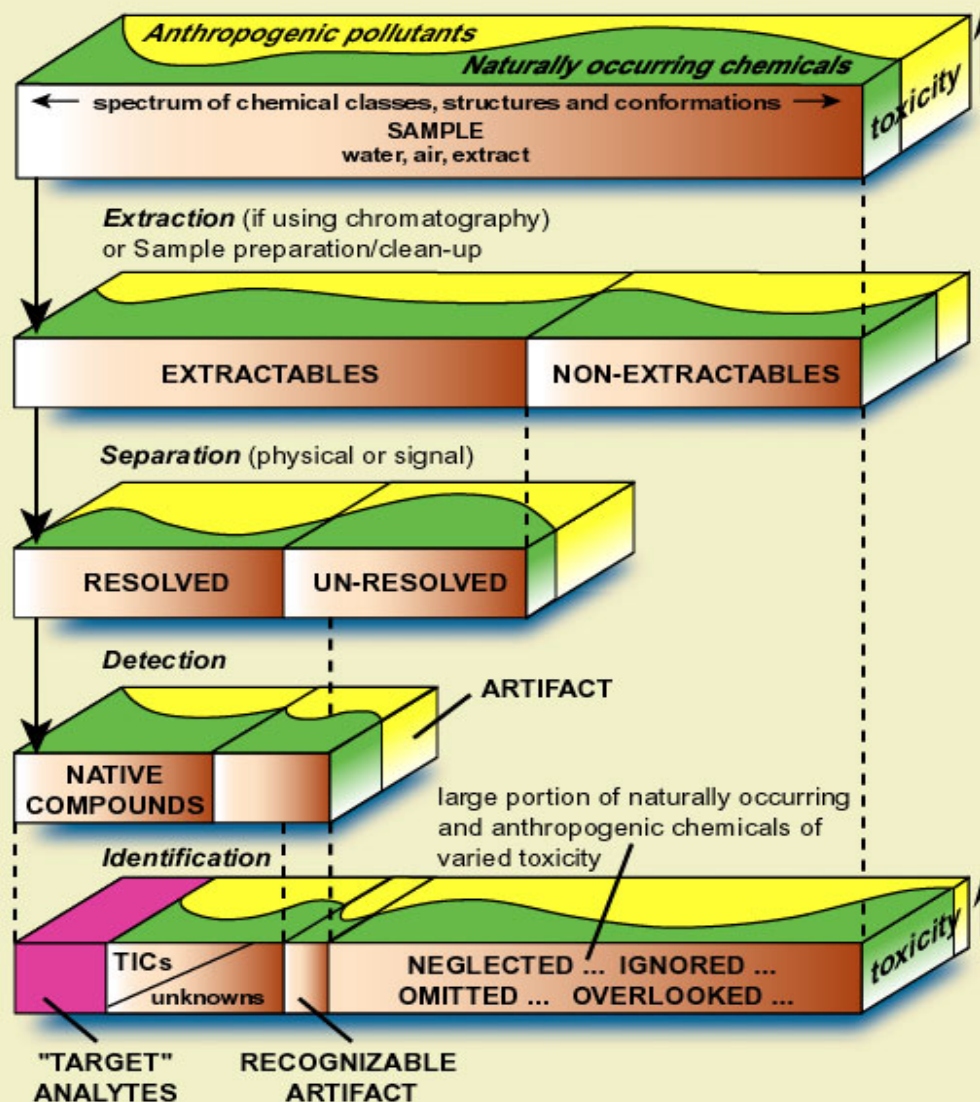
[†] it is important to recognize that the current “lists” of priority pollutants were primarily established in the 1970's in large part for expediency — that is, they could be measured with off-the-shelf chemical analysis technology. Priority pollutants were NOT necessarily selected solely on the basis of risk.

Universe of Chemicals in the Environment



C.G. Daughton
U.S. EPA July 2002

Limitations and Complexity of Environmental Chemical Analysis

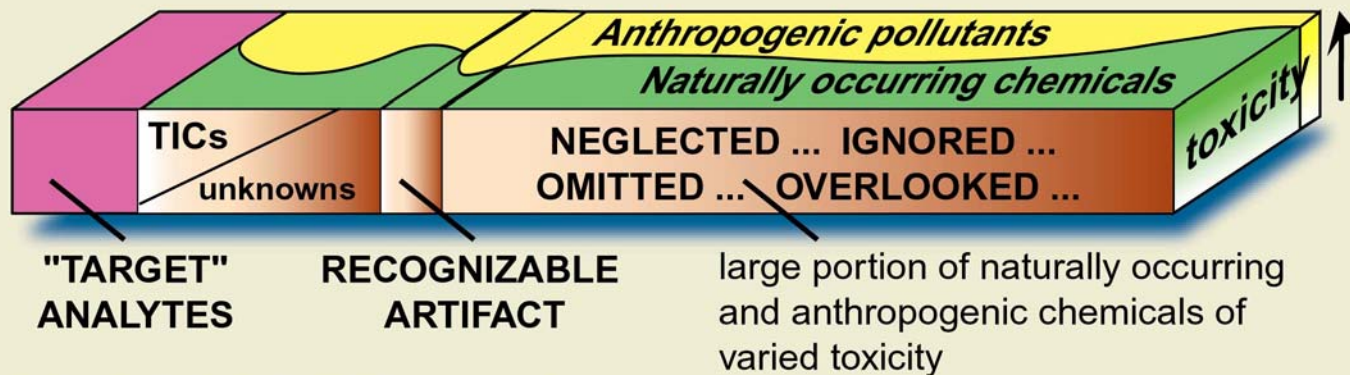


TICs = tentatively identified compounds

C.G. Daughton
U.S. EPA July 2002

274dc02-figure 2

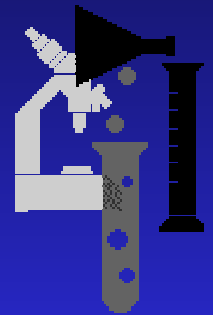
Chemical Analysis Output for a Typical Environmental Sample



TICs = tentatively identified compounds

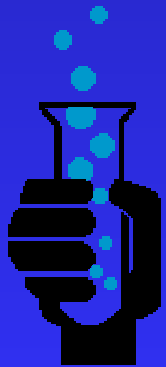
Einstein on: *Environmental Monitoring*

“Not everything that can be counted counts,
and not everything that counts can be
counted.” (oft attributed to Albert Einstein)



corollary for environmental monitoring

**Not everything that can be measured is
worth measuring, and not everything
worth measuring is measurable.**



further truisms regarding *Environmental Monitoring*

- What one finds usually depends on what one aims to search for.
- Only those compounds targeted for monitoring have the potential for being identified and quantified.
- Those compounds not targeted will elude detection.
- The spectrum of pollutants identified in a sample represent but a portion of those present and they are of unknown overall risk significance.

NOTE

Because of the size of this presentation, this file comprises only the 1st part of the entire PPCPs slide presentation. The subsequent parts must be accessed separately.

Continue with part 2...